

Day : Sunday
Date : 6/26/2005

Time : 10:07:50


PALM INTRANET

Inventor Name Search Result

Your Search was:

Last Name = ODAGAWA

First Name = AKIHIRO

Application#	Patent#	Status	Date Filed	Title	Inventor Name 50
<u>11061920</u>	Not Issued	030	02/22/2005	VARIABLE RESISTANCE ELEMENT, METHOD OF MANUFACTURING THE ELEMENT, MEMORY CONTAINING THE ELEMENT, AND METHOD OF DRIVING THE MEMORY	ODAGAWA, AKIHIRO
<u>11060028</u>	Not Issued	030	02/16/2005	MAGNETORESISTIVE ELEMENT AND MAGETORESISTIVE MAGNETIC HEAD, MAGNETIC RECORDING APPARATUS AND MAGNETORESISTIVE MEMORY DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>10896795</u>	Not Issued	030	07/22/2004	MAGNETIC HEAD AND APPARATUS FOR RECORDING/REPRODUCING MAGNETIC INFORMATION USING THE SAME	ODAGAWA, AKIHIRO
<u>10896774</u>	Not Issued	094	07/22/2004	MAGNETIC HEAD COMPRISING A MULTILAYER MAGNETORESISTIVE DEVICE AND A YOKE FOR INTRODUCING MAGNETIC FLUX FROM A MEDIUM TO THE MAGNETORESISTIVE DEVICE	ODAGAWA, AKIHIRO
<u>10877929</u>	Not Issued	041	06/25/2004	MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME, AS WELL AS MAGNETIC HEAD, MAGNETIC MEMORY AND MAGNETIC RECORDING DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>10871165</u>	Not Issued	030	06/18/2004	MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME	ODAGAWA, AKIHIRO

<u>10865130</u>	Not Issued	020	06/10/2004	THERMAL SWITCHING ELEMENT AND METHOD FOR MANUFACTURING THE SAME	ODAGAWA, AKIHIRO
<u>10848742</u>	Not Issued	041	05/17/2004	MAGNETO-RESISTIVE ELEMENT	ODAGAWA, AKIHIRO
<u>10783286</u>	<u>6839273</u>	150	02/20/2004	MAGNETIC SWITCHING DEVICE AND MAGNETIC MEMORY USING THE SAME	ODAGAWA, AKIHIRO
<u>10732053</u>	<u>6861940</u>	150	12/10/2003	MAGNETORESISTIVE ELEMENT	ODAGAWA, AKIHIRO
<u>10730096</u>	Not Issued	041	12/09/2003	THERMOELECTRIC TRANSDUCING MATERIAL, AND METHOD FOR PRODUCING THE SAME	ODAGAWA, AKIHIRO
<u>10719412</u>	Not Issued	094	11/21/2003	MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME, AS WELL AS MAGNETIC HEAD, MAGNETIC MEMORY AND MAGNETIC RECORDING DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>10717059</u>	Not Issued	030	11/18/2003	READER AND AUTHENTICATION DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>10695731</u>	Not Issued	092	10/24/2003	MAGNETIC MEMORY AND METHOD FOR DRIVING THE SAME, AND MAGNETIC MEMORY DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>10693283</u>	Not Issued	041	10/24/2003	MAGNETORESISTIVE ELEMENT AND METHOD FOR MANUFACTURING THE SAME	ODAGAWA, AKIHIRO
<u>10692362</u>	<u>6842317</u>	150	10/22/2003	MAGNETORESISTIVE ELEMENT, MAGNETIC HEAD, MAGNETIC MEMORY AND MAGNETIC RECORDING APPARATUS USING THE SAME	ODAGAWA, AKIHIRO
<u>10611224</u>	<u>6917492</u>	150	06/27/2003	MAGNETORESISTIVE ELEMENT AND METHOD FOR MANUFACTURING THE SAME AND NONVOLATILE MEMORY INCLUDING THE SAME	ODAGAWA, AKIHIRO
<u>10470670</u>	Not Issued	094	07/29/2003	MAGNETORESISTANCE ELEMENT AND MAGNETORESISTANCE STORAGE ELEMENT AND	ODAGAWA, AKIHIRO

				MAGNETIC MEMORY	
<u>10441794</u>	<u>6798620</u>	150	05/20/2003	MAGNETO-RESISTIVE ELEMENT, MAGNETIC HEAD, AND MAGNETIC RECORDING AND REPRODUCTION APPARATUS	ODAGAWA, AKIHIRO
<u>10421989</u>	<u>6708390</u>	150	04/23/2003	METHOD FOR MANUFACTURING MAGNETORESISTIVE ELEMENT	ODAGAWA, AKIHIRO
<u>10362871</u>	Not Issued	030	02/27/2003	AUTHENTICATION SYSTEM, AUTHENTICATION REQUEST DEVICE, VALIDATING DEVICE AND SERVICE MEDIUM	ODAGAWA, AKIHIRO
<u>10344296</u>	Not Issued	161	02/07/2003	MAGNETORESISTIVE ELEMENT	ODAGAWA, AKIHIRO
<u>10276966</u>	Not Issued	161	02/19/2003	MAGNETORESISTIVE ELEMENT AND MAGNETORESISTIVE MAGNETIC HEAD, MAGNETIC RECORDING APPARATUS AND MAGNETORESISTIVE MEMORY DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>10258313</u>	<u>6878979</u>	150	10/18/2002	SPIN SWITCH AND MAGNETIC STORAGE ELEMENT USING IT	ODAGAWA, AKIHIRO
<u>10250811</u>	Not Issued	092	07/08/2003	MAGNETIC STORAGE ELEMENT, PRODUCTION METHOD AND DRIVING METHOD THEREFOR, AND MEMORY ARRAY	ODAGAWA, AKIHIRO
<u>10250319</u>	<u>6778427</u>	150	06/26/2003	MAGNETORESISTANCE STORAGE ELEMENT	ODAGAWA, AKIHIRO
<u>10223875</u>	<u>6887717</u>	150	08/19/2002	MAGNETORESISTIVE DEVICE AND METHOD FOR PRODUCING THE SAME, AND MAGNETIC COMPONENT	ODAGAWA, AKIHIRO
<u>10052725</u>	<u>6771473</u>	150	01/18/2002	MAGNETORESISTIVE ELEMENT AND METHOD FOR PRODUCING THE SAME	ODAGAWA, AKIHIRO
<u>10038083</u>	<u>6555889</u>	150	01/03/2002	MAGNETORESISTIVE DEVICE AND METHOD FOR PRODUCING THE SAME, AND MAGNETIC COMPONENT	ODAGAWA, AKIHIRO
<u>10034895</u>	Not Issued	030	12/28/2001	MAGNETO-RESISTANCE EFFECT ELEMENT MAGNETO-RESISTANCE EFFECT MEMORY CELL, MRAM, AND METHOD	ODAGAWA, AKIHIRO

				FOR PERFORMING INFORMATION WRITE TO OR READ FROM THE MAGNETO- RESISTANCE EFFECT MEMORY CELL	
<u>10007454</u>	Not Issued	161	11/08/2001	MAGNETIC HEAD, AND MAGNETIC RECORDING AND REPRODUCTION APPARATUS	ODAGAWA, AKIHIRO
<u>09969558</u>	<u>6717780</u>	150	10/02/2001	MAGNETORESISTIVE DEVICE AND/OR MULTI- MAGNETORESISTIVE DEVICE	ODAGAWA, AKIHIRO
<u>09946643</u>	Not Issued	041	09/04/2001	MAGNETORESISTIVE ELEMENT, METHOD FOR MANUFACTURING THE SAME, AND MAGNETIC DEVICE USING THE SAME	ODAGAWA, AKIHIRO
<u>09931113</u>	<u>6767655</u>	150	08/16/2001	MAGNETO-RESISTIVE ELEMENT	ODAGAWA, AKIHIRO
<u>09864564</u>	<u>6594120</u>	150	05/23/2001	MAGNETORESISTIVE ELEMENT AND MAGNETIC MEMORY ELEMENT AND MAGNETIC HEAD USING THE SAME	ODAGAWA, AKIHIRO
<u>09856847</u>	<u>6778425</u>	150	08/22/2001	MAGNETORESISTANCE EFFECT MEMORY DEVICE AND METHOD FOR PRODUCING THE SAME	ODAGAWA, AKIHIRO
<u>09829400</u>	<u>6785100</u>	150	04/09/2001	MAGNETIC HEAD COMPRISING A MULTILAYER MAGNETORESISTIVE DEVICE AND A YOKE FOR INTRODUCING MAGNETIC FLUX FROM A MEDIUM TO THE MAGNETORESISTIVE DEVICE	ODAGAWA, AKIHIRO
<u>09804867</u>	<u>6538297</u>	150	03/13/2001	MAGNETO-RESISTIVE DEVICE AND MAGNETO-RESISTIVE EFFECT TYPE STORAGE DEVICE	ODAGAWA, AKIHIRO
<u>09803571</u>	<u>6590268</u>	150	03/09/2001	MAGNETIC CONTROL DEVICE, AND MAGNETIC COMPONENT AND MEMORY APPARATUS USING THE SAME	ODAGAWA, AKIHIRO
<u>09744513</u>	<u>6528326</u>	150	01/24/2001	MAGNETORESISTIVE DEVICE AND METHOD FOR PRODUCING THE SAME, AND MAGNETIC COMPONENT	ODAGAWA, AKIHIRO
<u>09597691</u>	Not	161	06/19/2000	SUPERCONDUCTING DEVICE	ODAGAWA,

	Issued			AND A METHOD OF MANUFACTURING THE SAME	AKIHIRO
<u>09596116</u>	<u>6436526</u>	150	06/16/2000	MAGNETO-RESISTANCE EFFECT ELEMENT, MAGNETO- RESISTANCE EFFECT MEMORY CELL, MRAM AND METHOD FOR PERFORMING INFORMATION WRITE TO OR READ FROM THE MAGNETO- RESISTANCE EFFECT MEMORY CELL	ODAGAWA, AKIHIRO
<u>09212721</u>	<u>6074768</u>	150	12/16/1998	PROCESS FOR FORMING THE OXIDE SUPERCONDUCTOR THIN FILM AND LAMINATE OF THE OXIDE SUPERCONDUCTOR THIN FILMS	ODAGAWA, AKIHIRO
<u>09082761</u>	<u>6147360</u>	150	05/21/1998	SUPERCONDUCTING DEVICE AND A METHOD OF MANUFACTURING THE SAME	ODAGAWA, AKIHIRO
<u>08888657</u>	<u>5885937</u>	150	07/07/1997	SUPERCONDUCTING TUNNEL JUNCTION ELEMENT AND SUPERCONDUCTING DEVICE	ODAGAWA, AKIHIRO
<u>08880914</u>	<u>5885939</u>	150	06/23/1997	PROCESS FOR FORMING A- AXIS-ON-C-AXIS DOUBLE- LAYER OXIDE SUPERCONDUCTOR FILMS	ODAGAWA, AKIHIRO
<u>08803940</u>	<u>6160266</u>	150	02/20/1997	SUPERCONDUCTING DEVICE AND A METHOD OF MANUFACTURING THE SAME	ODAGAWA, AKIHIRO
<u>08410447</u>	Not Issued	166	03/24/1995	PROCESS FOR FORMING THE OXIDE SUPERCONDUCTOR THIN FILM AND LAMINATE OF THE OXIDES SUPERCONDUCTOR THIN FILMS	ODAGAWA, AKIHIRO
<u>08328328</u>	<u>5719105</u>	150	10/24/1994	SUPERCONDUCTING ELEMENT	ODAGAWA, AKIHIRO
<u>08199813</u>	Not Issued	161	02/22/1994	OXIDE THIN FILM FORMING APPARATUS AND PROCESS OF FORMING THE OXIDE THIN FILM	ODAGAWA, AKIHIRO

[Search and Display More Records.](#)

Search Another: Inventor	Last Name	First Name	Search
	<input type="text" value="Odagawa"/>	<input type="text" value="Akihiro"/>	

To go back use Back button on your browser toolbar.

Back to [PALM](#) | [ASSIGNMENT](#) | [OASIS](#) | [Home page](#)

Hit List

[Clear](#)[Generate Collection](#)[Print](#)[Fwd Refs](#)[Bkwd Refs](#)[Generate OACS](#)

Search Results - Record(s) 1 through 10 of 14 returned.

☐ 1. Document ID: US 20050111124 A1

AB: A master carrier for magnetic transfer is equipped with a substrate having a land/groove pattern. The land/groove pattern is formed from a magnetic material and corresponds to information that is transferred to a magnetic recording disk. Each land in the land/groove pattern has four round corners whose radius is from 1% through 47% of the width of a data track on the disk.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	------	-----------

☐ 2. Document ID: US 20050024786 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. A first self-pinned layer having a first magnetic orientation is provided, wherein the first self-pinned layer has a first end, a second end and central portion. A second self-pinned layer is formed over only the central portion of the first self-pinned layer and an interlayer is disposed between the first and second self-pinned layers. A free layer is formed in a central region over the second self-pinned layer. First and second hard bias layers are formed over the first and second ends of the first self-pinned layer respectively, the first and second hard bias layer abutting the free layer, the first and second end of the first self-pinned layer extending under the hard bias layers at the first and second ends.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	------	-----------

☐ 3. Document ID: US 20050024785 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a free layer having a first end and a second end defining a width selected to form a desired trackwidth and an extended self-pinned bias layer extending beyond the ends of the free layer, the self-pinned bias layer extending beyond the free layer increasing the volume of the extended self-pinned bias layer to provide greater thermal stability and stronger pinning of the free layer.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 4. Document ID: US 20050024784 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a sandwiched hard bias layer having a first hard bias layer coupled to a free layer and a second, anti-parallel hard bias layer disposed away from the free layer to provide a net longitudinal bias on the free layer.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 5. Document ID: US 20050024783 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a self-pinned layer, the self-pinned layer having a first end, a second end and central portion, a free layer disposed over the central portion of the self-pinned layer in a central region and a first and second hard bias layers formed over the first and second ends of the self-pinned layer respectively, the first and second hard bias layer abutting the free layer, the first and second end of the self-pinned layer extending under the hard bias layers at the first and second ends.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 6. Document ID: US 20040120082 A1

AB: A method and apparatus for enhancing thermal stability, improving biasing and reducing damage from electrical surges in self-pinned abutted junction heads. The head includes a free layer having a first end and a second end defining a width selected to form a desired trackwidth and an extended self-pinned bias layer extending beyond the ends of the free layer, the self-pinned bias layer extending beyond the free layer increasing the volume of the extended self-pinned bias layer to provide greater thermal stability and stronger pinning of the free layer.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 7. Document ID: US 20030063403 A1

AB: A master carrier for magnetic transfer is equipped with a substrate having a land/groove pattern. The land/groove pattern is formed from a magnetic material and corresponds to information that is transferred to a magnetic recording disk. Each land in the land/groove pattern has four round corners whose radius is from 1% through 47% of the width of a data track on the disk.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 8. Document ID: US 20030002182 A1

AB: A magnetic transfer device for bringing a master carrier with information and a slave medium into intimate contact with each other and then applying a transfer field to transfer the information to the slave medium. The master carrier has an inclined face on its radially outer end. After the magnetic transfer of the information, claws are inserted in the gas formed by the inclined face of the master carrier and the slave medium. The slave medium held in intimate contact with the master carrier is separated from the master carrier by lifting the slave medium with the claws.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 9. Document ID: US 20020081461 A1

AB: There are provided an information recording medium which permits accurate tracking servo, and a method for recording and reproducing for an information recording medium which allows recording and reproducing of a signal at a favorable S/N by carrying out at least one of information recording and information reproduction while accurately performing tracking servo. A magneto-optic disk includes a magnetic recording layer for magnetically recording information. The magnetic recording layer is in advance magnetized for concentrically or spirally around the center of the disk in such a manner that magnetized regions are disposed such that adjacent regions are magnetized in different directions and alternately arranged in the radial direction of the disk. Accordingly, tracking can be continuously performed and accurate tracking servo can also be performed.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KMC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	-----	-----------

☐ 10. Document ID: US 20020058158 A1

AB: A magneto-resistive effect element includes a first ferromagnetic film; a second ferromagnetic film; and a first nonmagnetic film interposed between the first ferromagnetic film and the second

ferromagnetic film. The first ferromagnetic film has a magnetization more easily rotatable than a magnetization of the second ferromagnetic film by an external magnetic field. The first ferromagnetic film has an effective magnetic thickness of about 2 nm or less.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequences	Attachments	Claims	KWIC	Drawn Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-------------	--------	------	-----------

Clear	Generate Collection	Print	Fwd Refs	Bkwd Refs	Generate OACS
-------	---------------------	-------	----------	-----------	---------------

Terms	Documents
L4 and amorphous	14

Display Format:

[Previous Page](#)

[Next Page](#)

[Go to Doc#](#)

Hit List

[Clear](#)[Generate Collection](#)[Print](#)[Fwd Refs](#)[Bkwd Refs](#)[Generate OACS](#)

Search Results - Record(s) 11 through 14 of 14 returned.

☐ 11. Document ID: US 6909563 B2

AB: A master carrier for magnetic transfer is equipped with a substrate having a land/groove pattern. The land/groove pattern is formed from a magnetic material and corresponds to information that is transferred to a magnetic recording disk. Each land in the land/groove pattern has four round corners whose radius is from 1% through 47% of the width of a data track on the disk.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequence	Attachments	Claims	KWIC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	----------	-------------	--------	------	-----------

☐ 12. Document ID: US 6906875 B2

AB: A magnetic transfer device for bringing a master carrier with information and a slave medium into intimate contact with each other and then applying a transfer field to transfer the information to the slave medium. The master carrier has an inclined face on its radially outer end. After the magnetic transfer of the information, claws are inserted in the gas formed by the inclined face of the master carrier and the slave medium. The slave medium held in intimate contact with the master carrier is separated from the master carrier by lifting the slave medium with the claws.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Sequence	Attachments	Claims	KWIC	Draw. Des
------	-------	----------	-------	--------	----------------	------	-----------	----------	-------------	--------	------	-----------

☐ 13. Document ID: US 6829201 B2

AB: There are provided an information recording medium which permits accurate tracking servo, and a method for recording and reproducing for an information recording medium which allows recording and reproducing of a signal at a favorable S/N by carrying out at least one of information recording and information reproduction while accurately performing tracking servo. A magneto-optic disk includes a magnetic recording layer for magnetically recording information. The magnetic recording layer is in advance magnetized for concentrically or spirally around the center of the disk in such a manner that magnetized regions are disposed such that adjacent regions are magnetized in different directions and alternately arranged in the radial direction of the disk. Accordingly, tracking can be continuously performed and accurate tracking servo can also be performed.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Abstracts	Full Text	Claims	KMC	Draw Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-----------	--------	-----	----------

☐ 14. Document ID: US 6436526 B1

AB: A magneto-resistive effect element includes a first ferromagnetic film; a second ferromagnetic film; and a first nonmagnetic film interposed between the first ferromagnetic film and the second ferromagnetic film. The first ferromagnetic film has a magnetization more easily rotatable than a magnetization of the second ferromagnetic film by an external magnetic field. The first ferromagnetic film has an effective magnetic thickness of about 2 nm or less.

Full	Title	Citation	Front	Review	Classification	Date	Reference	Abstracts	Full Text	Claims	KMC	Draw Des
------	-------	----------	-------	--------	----------------	------	-----------	-----------	-----------	--------	-----	----------

Clear	Generate Collection	Print	Fwd Refs	Bkwd Refs	Generate OACS
-------	---------------------	-------	----------	-----------	---------------

Terms	Documents
L4 and amorphous	14

Display Format:

[Previous Page](#) [Next Page](#) [Go to Doc#](#)

Day : Sunday
Date: 6/26/2005

Time: 10:19:27

PALM INTRANET

Application Number Information

Application Number: 10/848742

Examiner Number: 78081 / BERNATZ, KEVIN

Assignments

Filing or 371(c) Date: 05/17/2004

Group Art Unit: 1773

IFW IMAGE

Effective Date: 05/17/2004

Class/Subclass:

428/692.000

Application Received: 05/20/2004

Lost Case: NO

Waiting for Response

Pat. Num./Pub. Num: /20040213071

Interference Number:

Desc.

Mail Non Final

Issue Date: 00/00/0000

Unmatched Petition: NO

Date of Abandonment: 00/00/0000

L&R Code: Secrecy Code:1

Attorney Docket Number: 10873.792USD1

Third Level Review: NO

Secrecy Order: NO

Status: 41 /NON FINAL ACTION MAILED

Status Date: 04/14/2005

Confirmation Number: 7331

Oral Hearing: NO

Title of Invention: MAGNETO-RESISTIVE ELEMENT

Bar Code	PALM Location	Location Date	Charge to Loc	Charge to Name	Employee Name	Location
----------	---------------	---------------	---------------	----------------	---------------	----------

Appln
Info

Contents

Petition Info

Atty/Agent Info

Continuity Data

Foreign Data

Inve

Search Another: Application#

or Patent#

PCT / /

or PG PUBS #

Attorney Docket #

Bar Code #

To go back use Back button on your browser toolbar.

Back to [PALM](#) | [ASSIGNMENT](#) | [OASIS](#) | [Home page](#)

US PATENT & TRADEMARK OFFICE

PATENT APPLICATION FULL TEXT AND IMAGE DATABASE



(1 of 1)

United States Patent Application**20040213071****Kind Code****A1****Hiramoto, Masayoshi ; et al.****October 28, 2004****Magneto-resistive element**

Abstract

The present invention provides a vertical current-type magneto-resistive element. The element includes an intermediate layer and a pair of magnetic layers sandwiching the intermediate layer, and at least one of a free magnetic layer and a pinned magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer. The element area defined by the area of the intermediate layer through which current flows perpendicular to the film is not larger than 1000 .mu.m.sup.2.

Inventors: **Hiramoto, Masayoshi;** (*Ikoma-shi, JP*) ; **Matukawa, Nozomu;** (*Nara-shi, JP*) ; **Odagawa, Akihiro;** (*Nara-shi, JP*) ; **Iijima, Kenji;** (*Kyoto-shi, JP*) ; **Sakakima, Hiroshi;** (*Kyotanabe-shi, JP*)

Correspondence **MERCHANT & GOULD PC**
Name and **P.O. BOX 2903**
Address: **MINNEAPOLIS**
MN
55402-0903
US

Assignee Name **MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.**
and Address: **Kadoma-shi**
JP
571-8501

Serial No.: **848742**
Series Code: **10**
Filed: **May 17, 2004**

U.S. Current Class:**365/232; 257/E21.665; 257/E27.005**

U.S. Class at Publication:

365/232

Intern'l Class:

G11C 008/02

Foreign Application Data

Date	Code	Application Number
Aug 21, 2000	JP	2000-249340
Oct 30, 2000	JP	2000-330254

Claims

1. A magneto-resistive element, comprising: an intermediate layer; and a pair of magnetic layers sandwiching the intermediate layer; wherein one of the magnetic layers is a free magnetic layer in which magnetization rotation with respect to an external magnetic field is easier than in the other magnetic layer; wherein the free magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than 1000 μm^2 ; and the non-magnetic layer has a thickness d in the range of 2.6 nm.ltoreq. $d < 10$ nm.

2. The magneto-resistive element according to claim 1, wherein an area of the free magnetic layer is larger than the element area.

3. The magneto-resistive element according to claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, M_m is an average saturation magnetization of the magnetic layers m and d_m is their respective average layer thickness, then magnetization of the magnetic layers m and d_m is their respective average layer thickness, then the sum of the products $M_m \cdot d_m$ for odd m is substantially equal to the sum of the products $M_m \cdot d_m$ for even m .

4. (Cancelled)

5. The magneto-resistive element according to any of claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, M_m is an average saturation magnetization of the magnetic layers m and d_m is their respective average layer thickness, then the sum of the products $M_m \cdot d_m$ for odd m is different from the sum of the products $M_m \cdot d_m$ for even m .

6-11 (Cancelled)

12. The magneto-resistive element according to claim 5, further comprising a second intermediate layer, wherein the free magnetic layer, which is made of a multilayer film, is sandwiched by the intermediate layers.

13. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of $2n$ magnetic layers (with n being an integer of 1 or greater) and $2n-1$ non-magnetic layers layered in alternation.

14. The magneto-resistive element according to claim 13, further comprising a first pinned magnetic

layer and a second pinned magnetic layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a non-magnetic layer and a second magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n (with n being 1 or 2) is d_n , and its average saturation magnetization is M_n , then $M_2 \cdot d_2 \neq M_1 \cdot d_1$.

15. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of $2n+1$ magnetic layers (with n being an integer of 1 or greater) and $2n$ non-magnetic layers layered in alternation.

16. The magneto-resistive element according to claim 15, further comprising a first pinned magnetic layer and a second pinned layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a first non-magnetic layer, a second magnetic layer, a second non-magnetic layer and a third magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n is d_n (with n being 1, 2 or 3), and its average saturation magnetization is M_n , then $M_3 \cdot d_3 + M_1 \cdot d_1 \neq M_2 \cdot d_2$.

17. The magneto-resistive element according to claim 1, wherein at least one of the magnetic layers in the free magnetic layer has a coercivity or saturation magnetization that is different from at least one of the other magnetic layers.

18-38 (Cancelled)

39. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

40. (Cancelled)

41. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of at least one metal selected from transition metals, or at least one conductive compound selected from compounds of transition metals with oxygen, nitrogen and boron; and wherein the element area is not larger than $0.01 \mu\text{m}^2$.

42. The magneto-resistive element according to claim 41, wherein at least one of the magnetic layers sandwiching the intermediate layer comprises a ferromagnetic material including oxygen, nitrogen or carbon, or an amorphous ferromagnetic material.

43-44 (Cancelled)

45. The magneto-resistive element according to claim 1, wherein the free magnetic layer serves as a magnetic memory layer.

46. (Cancelled)

47. The magneto-resistive element according to claim 1, further comprising a flux guide.

50. The magneto-resistive element according to claim 47, wherein at least a portion of the free magnetic layer serves as the flux guide.

49-50 (Cancelled)

51. The magneto-resistive element according to claim 1, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of $1.5 < a/b < 10$.

52-58 (Cancelled)

59. A data communication terminal equipped with a plurality of magneto-resistive elements according to claim 1, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto-resistive elements.

60. (Cancelled)

61. The magneto-resistive element according to claim 12, comprising a first pinned magnetic layer, a first intermediate layer, a first free magnetic layer, a non-magnetic conductive layer, a second free magnetic layer, an second intermediate layer and a second pinned magnetic layer formed in that order, wherein at least one of the first free magnetic layer and the second free magnetic layer includes one or more magnetic layers and one or more non-magnetic layers layered in alternation.

62. The magneto-resistive element according to claim 61, wherein magnetic layers that are adjacent but spaced apart by a non-magnetic conductive layer are magnetized antiparallel to one another.

63. The magneto-resistive element according to claim 61, wherein the non-magnetic conductive layer has a thickness of 2.6 nm to 50 nm.

64. (Cancelled)

65. The magneto-resistive element according to claim 1, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10 wt % to 50 wt % of a non-magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2 T.

66. The magneto-resistive element according to claim 65, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.

67-68 (Cancelled)

69. The magneto-resistive element according to claim 1, wherein the free magnetic layer is made of at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4 nm.

70. (Cancelled)

71. The magneto-resistive element according to claim 1, wherein the non-magnetic layer comprises at least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

Day : Sunday
Date: 6/26/2005

Time: 10:33:00

**PALM INTRANET****Application Number Information**

Application Number: 09/931113

Examiner Number: 79025 / UHLIR, NIKOLAS**Assignments**

Filing or 371(c) Date: 08/16/2001

Group Art Unit: 1773 IFW IMAGE

Effective Date: 08/16/2001

Class/Subclass: 428/692.000

Application Received: 08/17/2001

Lost Case: NO

Pat. Num./Pub. Num: 6767655/20020055016

Interference Number:

Issue Date: 07/27/2004

Unmatched Petition: NO

Date of Abandonment: 00/00/0000

L&R Code: Secrecy Code:1

Attorney Docket Number: 10873.792US01

Third Level Review: NO

Secrecy Order: NO

Status: 150 /PATENTED CASE

Status Date: 07/08/2004

Confirmation Number: 3656

Oral Hearing: NO

Title of Invention: MAGNETO-RESISTIVE ELEMENT

Bar Code	PALM Location	Location Date	Charge to Loc	Charge to Name	Employee Name	Location
----------	---------------	---------------	---------------	----------------	---------------	----------

**Appln
Info**[Contents](#)[Petition Info](#)[Atty/Agent Info](#)[Continuity Data](#)[Foreign Data](#)[Inve](#)Search Another: Application# or Patent# PCT / / or PG PUBS # Attorney Docket # Bar Code #

To go back use Back button on your browser toolbar.

Back to [PALM](#) | [ASSIGNMENT](#) | [OASIS](#) | [Home page](#)

US PATENT & TRADEMARK OFFICE

PATENT APPLICATION FULL TEXT AND IMAGE DATABASE



(1 of 1)

United States Patent Application**20020055016****Kind Code****A1****Hiramoto, Masayoshi ; et al.****May 9, 2002****Magneto-resistive element**

Abstract

The present invention provides a vertical current-type magneto-resistive element. The element includes an intermediate layer and a pair of magnetic layers sandwiching the intermediate layer, and at least one of a free magnetic layer and a pinned magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer. The element area defined by the area of the intermediate layer through which current flows perpendicular to the film is not larger than 1000 .mu.m.sup.2.

Inventors: **Hiramoto, Masayoshi;** (*Nara, JP*) ; **Matukawa, Nozomu;** (*Nara, JP*) ; **Odagawa, Akihiro;** (*Nara, JP*) ; **Iijima, Kenji;** (*Kyoto, JP*) ; **Sakakima, Hiroshi;** (*Kyoto, JP*)

Correspondence **MERCHANT & GOULD PC**

Name and **P.O. BOX 2903**

Address: **MINNEAPOLIS**

MN**55402-0903****US**

Serial No.: **931113**

Series Code: **09**

Filed: **August 16, 2001**

U.S. Current Class:

428/692; 257/E21.665; 257/E27.005

U.S. Class at Publication:

428/692

Intern'l Class:

G11B 005/127; B32B 009/00

Foreign Application Data

Date**Code****Application Number**

Aug 21, 2000

JP

2000-249340

Oct 30, 2000

JP

2000-330254

Claims

What is claimed is:

1. A magneto-resistive element, comprising: an intermediate layer; and a pair of magnetic layers sandwiching the intermediate layer; wherein one of the magnetic layers is a free magnetic layer in which magnetization rotation with respect to an external magnetic field is easier than in the other magnetic layer; wherein the free magnetic layer is a multilayer film including at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; and wherein an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than 1000 μm^2 .
2. The magneto-resistive element according to claim 1, wherein an area of the free magnetic layer is larger than the element area.
3. The magneto-resistive element according to claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, M_m is an average saturation magnetization of the magnetic layers m and d_m is their respective average layer thickness, then the sum of the products $M_m \cdot d_m$ for odd m is substantially equal to the sum of the products $M_m \cdot d_m$ for even m .
4. The magneto-resistive element according to claim 3, the non-magnetic layer has a thickness d in the range of 2.6 nm to $d < 10$ nm.
5. The magneto-resistive element according to any of claim 1, wherein, when the magnetic layers m are the magnetic layers in the free magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, M_m is an average saturation magnetization of the magnetic layers m and d_m is their respective average layer thickness, then the sum of the products $M_m \cdot d_m$ for odd m is different from the sum of the products $M_m \cdot d_m$ for even m .
6. The magneto-resistive element according to claim 5, the non-magnetic layer has a thickness d in the range of 2.6 nm to $d < 10$ nm.
7. The magneto-resistive element according to claim 5, wherein the non-magnetic layer has a thickness d in the range of 0.3 nm $< d < 2.6$ nm.
8. The magneto-resistive element according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d_1 , its average saturation magnetization is M_1 , an average film thickness of the second magnetic layer is d_2 , and its average saturation magnetization is M_2 , then 1) $1 < (M_1 \cdot d_1 + M_2 \cdot d_2) / S < 20$; (wherein S is the absolute value of $M_1 \cdot d_1 - M_2 \cdot d_2$); and 2) taking the effective film thickness d_{11} of the first magnetic layer as $d_{11} = (M_1 \cdot d_1 - M_2 \cdot d_2) / M_1$ when $M_1 \cdot d_1 - M_2 \cdot d_2 > 0$, and 3) taking the effective film thickness d_{22} of the second magnetic layer as $d_{22} = (M_2 \cdot d_2 - M_1 \cdot d_1) / M_2$ when $M_2 \cdot d_2 - M_1 \cdot d_1 > 0$, and taking as N_m the demagnetizing factor in a free magnetic layer surface in a direction of an applied external magnetic field, determined from the

effective film thickness d_{11} or d_{22} and the free magnetic layer surface shape, then $N_m < 0.02$.

9. The magneto-resistive element according to claim 5, wherein, when the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d_1 , its average saturation magnetization is M_1 , an average film thickness of the second magnetic layer is d_2 , and its average saturation magnetization is M_2 , then $M_2 \cdot d_2 > M_1 \cdot d_1$; and wherein the second magnetic layer is made of a soft magnetic material or a hard magnetic material, and the first magnetic layer is made of a high spin polarization material at least at an interface with the intermediate layer.

10. The magneto-resistive element according to claim 5, wherein, when the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the first magnetic layer is d_1 , its average saturation magnetization is M_1 , an average film thickness of the second magnetic layer is d_2 , and its average saturation magnetization is M_2 , then $M_2 \cdot d_2 > M_1 \cdot d_1$; and the magnetic resistance displays at least one maximum or minimum with respect to a change in the external magnetization.

11. The magneto-resistive element according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a first non-magnetic layer, second magnetic layer, a second non-magnetic layer, and a third magnetic layer, layered in that order from the intermediate layer, and when an average film thickness of the magnetic layer n is d_n , and its average saturation magnetization is M_n (with $n=1, 2, 3$), then $M_3 \cdot d_3 > M_1 \cdot d_1$ and $M_3 \cdot d_3 > M_2 \cdot d_2$; and wherein a coupling magnetic field of the first magnetic layer and the second magnetic layer is smaller than a memory reversal magnetic field, and the magnetization state of the third magnetic layer is detected by applying a magnetic field that is smaller than the memory reversal magnetic field but larger than the coupling magnetic field in a memory direction of the magnetization of the third magnetic layer.

12. The magneto-resistive element according to claim 5, further comprising a second intermediate layer, wherein the free magnetic layer, which is made of a multilayer film, is sandwiched by the intermediate layers.

13. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of $2n$ magnetic layers (with n being an integer of 1 or greater) and $2n-1$ non-magnetic layers layered in alternation.

14. The magneto-resistive element according to claim 13, further comprising a first pinned magnetic layer and a second pinned magnetic layer, wherein the first pinned magnetic layer, the first intermediate layer, the free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a non-magnetic layer and a second magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n (with n being 1 or 2) is d_n , and its average saturation magnetization is M_n , then $M_2 \cdot d_2 \neq M_1 \cdot d_1$.

15. The magneto-resistive element according to claim 12, wherein the free magnetic layer, which is made of a multilayer film, is made of $2n+1$ magnetic layers (with n being an integer of 1 or greater) and $2n$ non-magnetic layers layered in alternation.

16. The magneto-resistive element according to claim 15, further comprising a first pinned magnetic layer and a second pinned layer, wherein the first pinned magnetic layer, the first intermediate layer, the

free magnetic layer, the second intermediate layer and the second pinned magnetic layer formed in that order, wherein the free magnetic layer is a multilayer film comprising a first magnetic layer, a first non-magnetic layer, a second magnetic layer, a second non-magnetic layer and a third magnetic layer formed in that order from the side of the first pinned magnetic layer, and wherein, when an average film thickness of the magnetic layer n is d_n (with n being 1, 2 or 3), and its average saturation magnetization is M_n , then $M_3 \cdot d_3 + M_1 \cdot d_1 \neq M_2 \cdot d_2$.

17. The magneto-resistive element according to claim 1, wherein at least one of the magnetic layers in the free magnetic layer has a coercivity or saturation magnetization that is different from at least one of the other magnetic layers.

18. A magneto-resistive element comprising: a magneto-resistive element A according to claim 5, wherein the free magnetic layer comprises a first magnetic layer, a non-magnetic layer and a second magnetic layer, layered in that order from the intermediate layer, and wherein $M_2 \cdot d_2 > M_1 \cdot d_1$, when an average film thickness of the first magnetic layer is d_1 , its average saturation magnetization is M_1 , an average film thickness of the second magnetic layer is d_2 , and its average saturation magnetization is M_2 ; and further comprising a magneto-resistive element B having a second intermediate layer and a free magnetic layer that comprises a third magnetic layer and a fourth magnetic layer positioned in that order from the second intermediate layer, and wherein $M_3 \cdot d_3 > M_4 \cdot d_4$, when an average film thickness of the third magnetic layer is d_3 , its average saturation magnetization is M_3 , an average film thickness of the fourth magnetic layer is d_4 , and its average saturation magnetization is M_4 ; wherein the element A and the element B respond to the same external magnetic field, and the output of element A and element B are added to or subtracted from one another.

19. A magneto-resistive element, comprising: an intermediate layer; and a pair of magnetic layers sandwiching the intermediate layer; wherein one of the magnetic layers is a pinned magnetic layer in which magnetization rotation with respect to an external magnetic field is more difficult than in the other magnetic layer; wherein the pinned magnetic layer is a multilayer film comprising at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer; wherein a thickness d of the non-magnetic layer is in the range of $0.3 \text{ nm} < d < 2.6 \text{ nm}$; wherein the pinned magnetic layer is in contact with a primer layer or an antiferromagnetic layer; and wherein an element area, which is defined by the area of the intermediate layer through which current flows perpendicular to the film plane, is not larger than $1000 \text{ } \mu\text{m}^2$.

20. The magneto-resistive element according to claim 19, wherein, when the magnetic layers m are the magnetic layers in the pinned magnetic layer that are arranged at positions m (with m being an integer of 1 or greater) from the intermediate layer, M_m is an average saturation magnetization of the magnetic layers m and d_m is their respective average layer thickness, then the sum of the products $M_m \cdot d_m$ for odd m is substantially equal to the sum of the products $M_m \cdot d_m$ for even m .

21. A magneto-resistive element comprising: a magneto-resistive element A including a first pinned magnetic layer, in which $2n$ magnetic layers and $2n-1$ non-magnetic layers (with n being an integer of 1 or greater) are layered in alternation from the intermediate layer; and a magneto-resistive element B, including a second pinned magnetic layer, in which $2n+1$ magnetic layers and $2n$ non-magnetic layers are layered in alternation from the intermediate layer; wherein at least one of the element A and the element B is as claimed in claim 19; wherein the element A and the element B respond to the same external magnetic field; and wherein the outputs of element A and element B are added to or subtracted from one another.

22. The magneto-resistive element according to claim 19, wherein the non-magnetic layer comprises at

least one compound selected from the group consisting of oxides, nitrides, carbides and borides.

23. The magneto-resistive element according to claim 22, wherein the non-magnetic layer is a multilayer film including at least one layer of non-magnetic metal and at least one layer of non-magnetic material selected from the group consisting of oxides, nitrides, carbides and borides.

24. The magneto-resistive element according to claim 19, wherein the primer layer includes at least one element selected from the elements of groups IVa to VIa and VIII (but excluding Fe, Co and Ni) and Cu.

25. The magneto-resistive element according to claim 19, wherein the primer layer is in contact with a magnetic layer, and the primer layer and that magnetic layer have at least one crystal structure selected from fcc and hcp structure, or the primer layer and that magnetic layer both include a bcc structure.

26. The magneto-resistive element according to claim 19, wherein the antiferromagnetic layer is made of Cr and at least one selected from the group consisting of Mn, Tc, Ru, Rh, Re, Os, Ir, Pd, Pt, Ag, Au and Al.

27. The magneto-resistive element according to claim 26, wherein the antiferromagnetic layer has a composition that can be expressed by $\text{Cr.sub.100-xMe.sub.x}$ (wherein Me is at least one selected from the group consisting of Re, Ru and Rh, and $0.1.\text{ltoreq.X.litoreq.20}$).

28. The magneto-resistive element according to claim 19, wherein the antiferromagnetic layer has a composition that can be expressed by $\text{Mn.sub.100-xMe.sub.x}$ (wherein Me is at least one selected from the group consisting of Pd Pt, and $40.\text{ltoreq.X.litoreq.55}$).

29. The magneto-resistive element according to claim 19, wherein the antiferromagnetic layer is formed on a primer layer, and the primer layer and the antiferromagnetic layer include at least one crystal structure selected from fcc, fct, hcp and hct structure, or the primer layer and the antiferromagnetic layer both include a bcc structure.

30. The magneto-resistive element according to claim 29, wherein the primer layer is made of NiFe or NiFeCr; and which has been thermally processed at a temperature of at least 300.degree. C.

31. The magneto-resistive element according to claim 19, wherein at least the magnetic layer in contact with the antiferromagnetic layer is made of Co.

32. The magneto-resistive element according to claim 19, wherein the magnetic layer in contact with at least one selected from the antiferromagnetic layer and the non-magnetic layer is made of a ferromagnetic material including at least one element selected from the group consisting of oxygen, nitrogen and carbon.

33. The magneto-resistive element according to claim 19, wherein the magnetic layer in contact with at least one selected from the antiferromagnetic layer and the non-magnetic layer is made of an amorphous ferromagnetic material.

34. The magneto-resistive element according to claim 19, wherein, when d_f is a thickness of the pinned magnetic layer, and d_a is a thickness of the ferromagnetic layer, then $2\text{ nm.litoreq.d_f.litoreq.50 nm}$, $5\text{ nm.litoreq.d_a.litoreq.100 nm}$, $0.1\text{ nm.litoreq.d_f/d_a.litoreq.5}$.

35. The magneto-resistive element according to claim 1, further comprising a lower electrode made of a

metal multilayer film, wherein the magneto-resistive element is formed on the lower electrode.

36. The magneto-resistive element according to claim 35, wherein the multilayer film has a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al and Cu as a main component, and a grain-growth suppression layer of an metal having at least one element selected from groups IVa to VIa and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, conductive nitrides and conductive carbides.

37. The magneto-resistive element according to claim 19, further comprising a lower electrode made of a metal multilayer film, wherein the magneto-resistive element is formed on the lower electrode.

38. The magneto-resistive element according to claim 37, wherein the multilayer film has a multilayer structure including a highly conductive metal layer (i) having at least one selected from the group consisting of Ag, Au, Al and Cu as a main component, and a grain-growth suppression layer of an metal having at least one element selected from groups IVa to VIa and VIII as a main component, or (ii) of a compound selected from the group consisting of conductive oxides, conductive nitrides and conductive carbides.

39. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

40. The magneto-resistive element according to claim 19, wherein the intermediate layer is made of an insulator or a semiconductor including at least one element selected from the group consisting of oxygen, nitrogen, carbon and boron.

41. The magneto-resistive element according to claim 1, wherein the intermediate layer is made of at least one metal selected from transition metals, or at least one conductive compound selected from compounds of transition metals with oxygen, nitrogen and boron; and wherein the element area is not larger than $0.01 \mu\text{m}^2$.

42. The magneto-resistive element according to claim 41, wherein at least one of the magnetic layers sandwiching the intermediate layer comprises a ferromagnetic material including oxygen, nitrogen or carbon, or an amorphous ferromagnetic material.

43. The magneto-resistive element according to claim 19, wherein the intermediate layer is made of at least one metal selected from transition metals, or at least one conductive compound selected from compounds of transition metals with oxygen, nitrogen and boron; and wherein the element area is not larger than $0.01 \mu\text{m}^2$.

44. The magneto-resistive element according to claim 43, wherein at least one of the magnetic layers sandwiching the intermediate layer comprises a ferromagnetic material including oxygen, nitrogen or carbon, or an amorphous ferromagnetic material.

45. The magneto-resistive element according to claim 1, wherein the free magnetic layer serves as a magnetic memory layer.

46. The magneto-resistive element according to claim 19, wherein the free magnetic layer serves as a magnetic memory layer.

47. The magneto-resistive element according to claim 1, further comprising a flux guide.
48. The magneto-resistive element according to claim 47, wherein at least a portion of the free magnetic layer serves as the flux guide.
49. The magneto-resistive element according to claim 19, further comprising a flux guide.
50. The magneto-resistive element according to claim 49, wherein at least a portion of the free magnetic layer serves as the flux guide.
51. The magneto-resistive element according to claim 1, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of $1.5 < a/b < 10$.
52. The magneto-resistive element according to claim 19, wherein, when "a" is the longest width of the element shape of the free magnetic layer, and "b" is its shortest width, then a/b is in the range of $1.5 < a/b < 10$.
53. A method for manufacturing a magneto-resistive element according to claim 1, comprising additional heat treatment in a magnetic field at 200.degree. C. to 400.degree. C., after heat treatment at 300.degree. C. to 450.degree. C.
54. A method for manufacturing a magneto-resistive element according to claim 19, comprising additional heat treatment in a magnetic field at 200.degree. C. to 400.degree. C., after heat treatment at 300.degree. C. to 450.degree. C.
55. A method for manufacturing a magneto-resistive element according to claim 1, comprising heat treatment in a magnetic field at 300.degree. C. to 450.degree. C.
56. A method for manufacturing a magneto-resistive element according to claim 19, comprising heat treatment in a magnetic field at 300.degree. C. to 450.degree. C.
57. A method for manufacturing a magneto-resistive element according to claim 1, comprising: forming a multilayer film including an antiferromagnetic layer, a pinned layer, an intermediate layer and a free magnetic layer on a substrate; providing a uniaxial anisotropy by performing heat treatment in a magnetic field at 200.degree. C. to 350.degree. C.; performing additional heat treatment in a reducing atmosphere at 300.degree. C. to 450.degree. C.
58. A method for manufacturing a magneto-resistive element according to claim 19, comprising: forming a multilayer film including an antiferromagnetic layer, a pinned layer, an intermediate layer and a free magnetic layer on a substrate; providing a uniaxial anisotropy by performing heat treatment in a magnetic field at 200.degree. C. to 350.degree. C.; performing additional heat treatment in a reducing atmosphere at 300.degree. C. to 450.degree. C.
59. A data communication terminal equipped with a plurality of magneto-resistive elements according to claim 1, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto-resistive elements.
60. A data communication terminal equipped with a plurality of magneto-resistive elements according to claim 19, wherein data that have been communicated by electromagnetic waves are stored in the free magnetic layers of the magneto-resistive elements.

61. The magneto-resistive element according to claim 12, comprising a first pinned magnetic layer, a first intermediate layer, a first free magnetic layer, a non-magnetic conductive layer, a second free magnetic layer, an second intermediate layer and a second pinned magnetic layer formed in that order, wherein at least one of the first free magnetic layer and the second free magnetic layer includes one or more magnetic layers and one or more non-magnetic layers layered in alternation.
62. The magneto-resistive element according to claim 61, wherein magnetic layers that are adjacent but spaced apart by a non-magnetic conductive layer are magnetized antiparallel to one another.
63. The magneto-resistive element according to claim 61, wherein the non-magnetic conductive layer has a thickness of 2.6 nm to 50 nm.
64. The magneto-resistive element according to claim 12, comprising four pinned magnetic layers, two free magnetic layers, and four intermediate layers, wherein at least one of the free magnetic layers is made of one or more magnetic layers and one or more non-magnetic layers layered in alternation.
65. The magneto-resistive element according to claim 1, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10 wt % to 50 wt % of a non-magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2 T.
66. The magneto-resistive element according to claim 65, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.
67. The magneto-resistive element according to claim 19, comprising a pinned magnetic layer, an intermediate layer and a free magnetic layer, wherein the free magnetic layer is in contact with a buffer layer, wherein the buffer layer is made of a composition in which 10 wt % to 50 wt % of a non-magnetic element is added to a composition of a magnetic layer in contact with the buffer layer, and wherein the saturation magnetization of said composition is not more than 0.2 T.
68. The magneto-resistive element according to claim 67, wherein the buffer layer comprises at least one selected from the group consisting of Cr, Mo and W.
69. The magneto-resistive element according to claim 1, wherein the free magnetic layer is made of at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4 nm.
70. The magneto-resistive element according to claim 19, wherein the free magnetic layer is made of at least one non-magnetic layer and magnetic layers sandwiching the non-magnetic layer, and wherein a total film thickness of the magnetic layers is at least 4 nm.
71. The magneto-resistive element according to claim 1, wherein the non-magnetic layer comprises at least one compound selected from the group consisting of oxides, nitrides, carbides and borides.
72. The magneto-resistive element according to claim 71, wherein the non-magnetic layer is a multilayer film including at least one layer of non-magnetic metal and at least one layer of non-magnetic material selected from the group consisting of oxides, nitrides, carbides and borides.

Description